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(54) A MICROWAVE DIRECTIONAL STRIPLINE ANTENNA

(71) We, LICENTIA PATENT VERWALTUNGS G.m.b.H., of 1 Theodor-Stern-Kai, 6 Frankfurt/Main 70, Federal Republic of Germany, a German body corporate, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a microwave directional strip-line antenna in strip line technology.

These antennae which are designed as microstrip antennae are suitable for any desired applications in the GHz-range, particularly if the smallest possible half-field-strength beam widths are necessary with given dimensions of the antenna or if the smallest possible dimensions are necessary to give a particular half-field-strength beam-width.

"Comb-shaped" microstrip antennae are already known from the paper entitled "Comb-shaped microstrip antennae", J. R. James and G. J. Wilson, New Design Techniques for Microstrip Antenna Arrays, at the Microwave conference 1975 in Hamburg, in which microstrip antennae $\lambda/2$ stub lines are connected to a base line (a microstrip line) respectively, the stub lines being arranged at a spacing λ perpendicular to the base line, in which λ is the wavelength at the intended operating frequency of the antenna. The disadvantage of these antennae may be seen particularly in the fact that their half-field-strength beamwidth is too large and they have too small a gain for many applications and that design of these antennae is moreover too expensive.

The invention seeks to create microwave directional stripline antennae which are simple to design and easily manufactured, these antennae having the narrowest possible radiation pattern with a high gain for given dimensions or having the smallest possible dimensions for a given half-field-strength beamwidth and side lobe suppression.

According to the invention, there is provided a microwave directional stripline antenna comprising a plurality of strip line elements of which at least some are of different widths and which all have a length of approximately $\lambda/2$ where λ is the wavelength at the intended operating frequency of the antenna, the strip line elements being conductively connected in series.

In an advantageous refinement provision may be made for alternately wide and narrow elements and for all wide strip line elements and all strip line elements respectively to have the same width.

A further favourable embodiment has alternately wide and narrow strip line elements connected in series alternately, the width of the wide and/or narrow strip line elements being decreased gradually from element to element either from a centre of symmetry of the directional antenna to both ends of the antenna or from one end of the directional antenna to the other.

A preferred embodiment consists in that the width of the series-connected strip line elements decreases stepwise either from a centre of symmetry of the directional antenna to both ends of the antenna or from one end of the directional antenna to the other.

With narrower band widths embodiments, provision may be made for the length of the individual strip line elements to deviate from the length $\lambda/2$ by same amount for all strip line elements, while the lengths deviate slightly differently from element to element in wider band width embodiments.

The feed point of the antenna may be arranged at one open end of the antenna or at the beginning or end of any desired strip line element.

An advantageous further refinement may be obtained by connecting two or more series circuits made up of strip line elements conductively connected in line current direction in parallel to each other from the purpose of further reducing the half-field-strength beam width of the antennae in the direction of a plane transverse to the plane containing the elements in which the feed point is provided at one end of the antenna or at the beginning or end of any desired strip line element.

The particular advantage of the antennae in accordance with the invention with respect to those known lies in the fact that they have a smaller half-field-strength beam-width and hence a higher gain than the known antennae of otherwise equal data. Their extremely narrow directional characteristics cannot be achieved by means of the known antennae with the same dimensions. In addition simplification of the design is possible because side lobe suppression and half-field-strength are associated simply with particular dimensions and changes take place in a contrary direction to changes in half-field-strength beam-width and manufacture of these antennae can take place at a favourable cost.

The invention will now be described in greater detail, by way of example with reference to the drawings, in which:—

Figure 1*a* shows an embodiment of a microwave directional antenna in accordance with the invention in plan view;

Figure 1*b* shows a longitudinal section through the microwave directional antenna according to Figure 1*a* in side view;

Figures 2 to 4 show further embodiments of the microwave directional antenna in accordance with the invention; and

Figure 5 shows the radiation pattern of the microwave directional antenna according to Figure 1*a* with q=0.54.

Referring to Figures 1*a* and 1*b*, the antenna has a metallic baseplate 4 which is provided on one side of a dielectric layer 3. The free surface of the dielectric layer 3 carries n strip line elements 1^1 to 1^n, the length of which l_1 to l_n amounts to approximately $\lambda/2$ respectively, in which λ means the wavelength at the intended frequency of the strip line or microstrip which is dependent on the thickness and the dielectric constant of the dielectric layer 3 as well as on the width of the strip line elements. The strip line elements 1^1 to 1^n are conductively connected in series in the current direction. The width b_1 to b_n of the individual elements may be different. With the present embodiment a wide strip line element alternates effectively with a narrow one in which the widths b_1, b_3, b_5 ... of all the wide elements and the widths b_2, b_4, b_6 ...of all the narrow elements are the same as each other. The antenna is fed from the rear side at a feed point 2 — i.e. from the side of the baseplate 4. The feed point is arranged in this case at a point between the ends of two adjacent elements inside the antennae, however the free ends of the end elements 1_1 and 1_n are equally suitable as a feed point. By simply changing the quotients q of the width of the narrow stripline elements divided by the width of the wide strip line elements the half-field-strength beam-width of the antenna may be continuously changed within the limits $0 = \leq q \leq 1$ from a maximum value at q=0 to a minimum value at q=1, in which the maximum and minimum of the half-field-strength beam-width in turn depends on the number *n* of the elements. By changing the quotient q, the side lobe suppression also changes at the same time — however, in a contrary direction to the change of the half-field-strength beam-width. With an antenna having nine wide and eight narrow strip line elements the half-field-strength beam-width may change for example between about 9° and 5° while the side lobe suppression varies at the same time between −20 dB and 0 dB. The measured radiation pattern of an antenna having *q*=0.54 is shown in Figure 5. The antenna has a half-field-strength beam-width of approximately 6.5°, a gain of approximately 16 dB and a side lobe suppression of approximately −10 dB. These values cannot be achieved with the known microstrip antennae.

With a fixed number of elements (synonymous with predetermining the dimensions of the antennae) design of the antenna is made considerably easier because of the simple relationship between the quotient *q* on the one hand and the half-field-strength beam-width and side lobe suppression on the other hand as mentioned. A particular half-field-strength beam-width and side lobe suppression is associated with each value of the quotient *q* so that, for example, with a given half-field-strength beam-width it is known straight away what side lobe suppression is associated with it and how the ratio *q* of the widths of the narrow and wide elements should be selected.

Figure 2 shows an embodiment in which the width of the wide and the width of the narrow strip line elements decreases gradually from element to element from a centre of symmetry of the directional antenna to both ends. The side lobe suppression of the antenna may be improved by this use of stepped widths.

A modification of the antenna according to Figure 2 is shown in Figure 3 in which the width of the strip line elements decreases continuously from element to element from a centre of symmetry of the antenna to both ends of the antenna.

According to the shape of the radiation

pattern which is sought after, the width of the elements in the antennae according to Figures 2 and 3 may alternatively decrease from both ends of the antenna to the centre of symmetry or from one end of the antenna to the other instead of from the centre outwards.

Figure 4 shows an embodiment in which three antennae according to Figure 1*a* are connected in parallel by means of a conductive crosspiece 5. The parallel connection of several antenna facilitates additional reduction of the half-field-strength bandwidth in the plane transverse to the plane containing the elements. Feed takes place via a feed point 2 at the beginning or end of any of the strip line elements.

It is to be understood that because of different effects, the effective length of a strip line deviates from its geometric length. Thus the length of the individual strip line elements will deviate from the length $\lambda/2$. This deviation may be made the same for all strip line elements or it may lay slightly from one strip line element to another for reasons of bandwidth.

WHAT WE CLAIM IS:—

1. A microwave directional strip line antenna comprising a plurality of strip line elements of which at least some are of different widths and which all have a length of approximately $\lambda/2$ where λ is the wavelength at the intended operating frequency of the antenna, the strip line elements being conductively connected in series.

2. A microwave directional antenna according to claim 1, wherein when series-connecting the strip line elements, wide and narrow elements are provided alternately; and that all wide strip line elements and all narrow strip line elements respectively have the same width.

3. A microwave directional antenna according to claim 1, characterized in that wide and narrow strip line elements are connected in series alternately and that the width of the wide and/or the narrow strip line elements is decreased gradually from element to element either from a centre of symmetry of the directional antenna to both ends or from one end of the directional antenna to the other.

4. A microwave directional antenna according to claim 1, wherein the width of the series-connecting strip line elements decreases step wise either from a centre of symmetry of the directional antenna to both ends of the antenna or from one end of the directional antenna to the other.

5. A microwave directional antenna according to any one of claims 1 to 4, wherein the length of the individual strip line elements deviates from the length $\lambda/2$ by the same amount in all strip line elements.

6. A microwave directional antenna according to any one of claims 1 to 4, wherein the length of the individual strip line elements deviates from the length $\lambda/2$ for reasons of band width slightly differently from element to element.

7. A microwave directional antenna according to any one of claims 1 to 6, wherein the antenna feed point is arranged at one end of the antenna or at the beginning or end of any desired strip line element.

8. A microwave directional antenna according to any one of claims 1 to 7, wherein, in order to reduce the half-field-strength bandwidth of the antenna in a plane transverse to the plane containing the elements, two or more circuits made up of series connected strip line elements are connected in parallel, in which the feed point is provided at one end of the antenna or at the beginning or end of any desired strip line element.

9. A microwave directional antenna substantially as described herein with reference to any one of Figures 1 to 4 of the drawings.

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Reference has been directed in pursuance of section 9, subsection (1) of the Patents Act 1949, to Patent No. 1,532,731.

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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG.1a

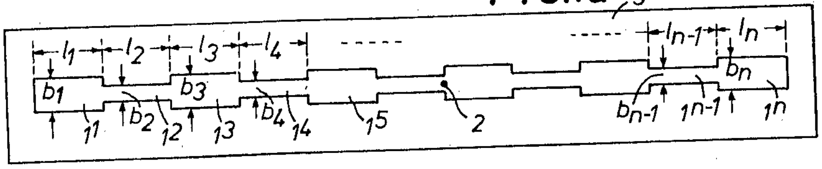


FIG.1b

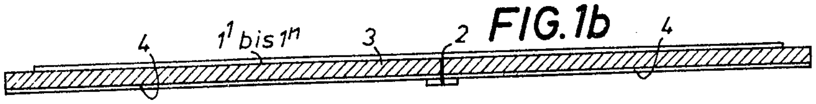


FIG.2

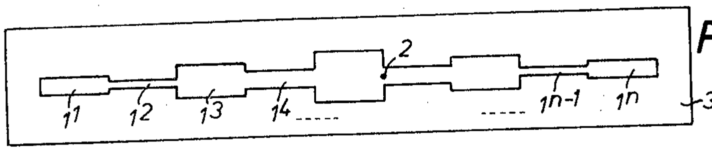


FIG.3

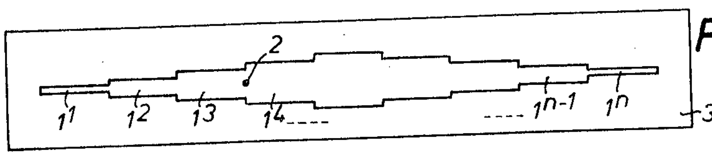
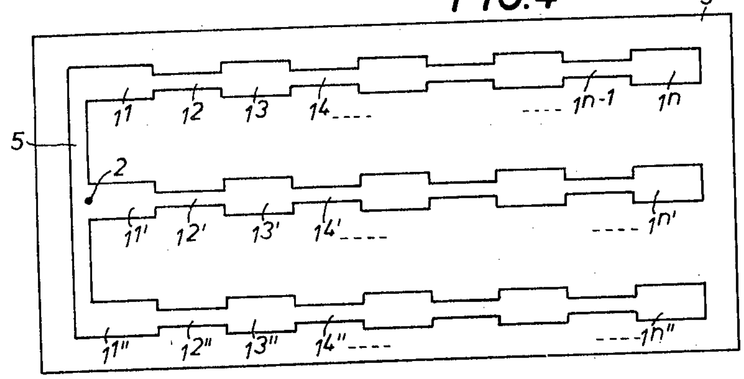


FIG.4



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Sheet 2

FIG.5